U. S. ARMY AIR FORCES, TACTICAL CENTER, ORLANDO, FLA. ARCTIC, DESERT AND TROPICAL BRANCH

IMPROVISED COMBAT SANITATION

RESTRICTED

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IMPROVISED COMBAT SANITATION

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U.S. Army Air Forces, Tactical Center,
Orlando, Fla. Arctic, Desert and Tropic Branch

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SECTION I

INTRODUCTION

PURPOSE.

The purpose of this publication is to present to commanders of AAF units and to medical officers methods for improvising sanitary facilities from salvage equipment. This is in accordance with WD Training Circular 48, 1943, which emphasizes the importance of improvised field expedients, and with AAF Regulation 50-12, 1943. Under many combat conditions, standard equipment may not be available or may fail to function. Some of the improvisations serve better than prescribed equipment, and all are easy to construct.

SOURCE.

The material presented herewith has been derived: (1) from the experiences of medical officers who have returned from overseas theaters, (2) from field tests carried on at the AAF Medical Service Training School at Robins Field, Georgia, and (3) from current military and medical publications. All of the devices have been field tested.

APPLICATION.

The establishment of healthful living conditions for AAF units may be made difficult by any or all of the following factors: excessive rainfall, high humidity, poor soil drainage, high water level, raw water unfit for drinking, lack of wood for fuel (or wet wood), and serious endemic diseases. These difficulties are encountered most frequently in tropical theaters. The improvisations to be described are especially intended to promote good sanitation in the tropics, but are equally applicable in other climates and terrains.

FLEXIBILITY OF IMPROVISED METHODS.

The improvisations described in this publication suggest various ways of solving sanitary problems. The descriptions of methods and facilities are not meant to be hard-and-fast blueprints. Emphasis is laid on the flexible use of a practical basic principle and not on rigid adherence to fixed measurements and specific materials. For this reason, only the essential dimensions of the various devices are given, and *specific* parts are named only if those particular parts are *absolutely* required.

The flexibility of the principles upon which the various devices are based makes it possible for any unit to achieve successful results, even though there is considerable difference between units in the contents of their salvage piles and their Tables of Equipment.

AAF UNIT FACILITIES.

AAF units usually are established in installations of a semi-permanent nature. Even in rapid combat advances, these bases continue in use for weeks or months. Except during the short period required for the installation of the unit, there is little necessity for relying on temporary or makeshift personal measures of sanitary control and disease prevention.

The degree of success attained in improvising sanitary devices depends upon the amount of ingenuity and industry displayed by the unit. Almost every AAF unit has the means *within itself* for overcoming sanitary problems and establishing effective facilities in semipermanent installations in any climate or terrain.

SKILLS AND TOOLS.— There are welders, sheet metal workers, electrical specialists, carpenters, fabric and dope workers, pump operators, and oxygen equipment experts in all AAF units. Each is equipped with the tools peculiar to his trade.

MATERIAL.—Aircraft salvage piles are available to almost all AAF units. Such materials include: oil drums and fuel containers of various sizes, sheet metal, oxygen line, piping, booster pumps, energizers, oxygen tanks, and other items. Captured enemy equipment may include useful material.

RESPONSIBILITY FOR SANITATION.

The unit commander is charged with the responsibility for the health, welfare, and morale of his men. The success with which this responsibility is discharged depends largely upon the early institution of good sanitary measures. It will be necessary to assign specialists, such as welders and sheet metal workers, to duty on sanitary construction details. The amount of time required of these specialists is small and will be repaid many times by the better health and morale of all. Moreover, it is important to assign conscientious and intelligent men, permanently or in rotation, to the operation of sanitation facilities. Combat experience has proved that carelessness results in threats to health.

The medical officer and medical department enlisted men act in an advisory capacity to the commanding officer. This advice should be based upon an understanding of the special problems created by terrain, climate, and endemic diseases. Medical department personnel are not directly responsible for the construction or maintenance of sanitation facilities. However, the responsibility probably will be delegated by the commanding officer to the medical officer. All medical and line officers should be familiar with expedients which will function when prescribed sanitary methods fail.

The unit will derive the greatest benefit when the commander and the medical officer cooperate fully.

Note

From time to time, as new information is received from the field and tested, additional information will be distributed for inclusion in this publication. All AAF units are invited to contribute descriptions and illustrations of sanitation devices which, in their opinion, warrant consideration. Address all communications to the Director, Arctic, Desert and Tropic Branch, Army Air Forces Tactical Center, Attention Medical Section, Orlando, Florida.

SECTION II

HEATING DEVICES

In combat areas a reliable source of heat is the most important single requirement for improvised sanitation. Only heaters which burn waste oil meet the requirement; fuel wood cannot be depended upon at all times in combat theaters. This is especially true in the tropics. On reefs, atolls, and small islands fuel wood is scarce; in tropical rain-forests, it is usually wet.

This section describes the principles, construction, and operation of improvised heating devices. These devices are used to furnish boiling water for messkit washing, showers, shaving, and laundry; also, they provide a means of incinerating garbage and feces. The methods of adapting improvised heaters to these sanitation uses are discussed in the appropriate sections.

Various methods of burning liquid oil in sand-filled containers have been used, but these have proved wasteful of fuel and undesirable because of the black oily smoke produced.

The heaters described below use waste oil for fuel but cause little or no smoke nuisance. They are simple to construct, easy to operate, produce great heat, and have proved practical in combat experience.

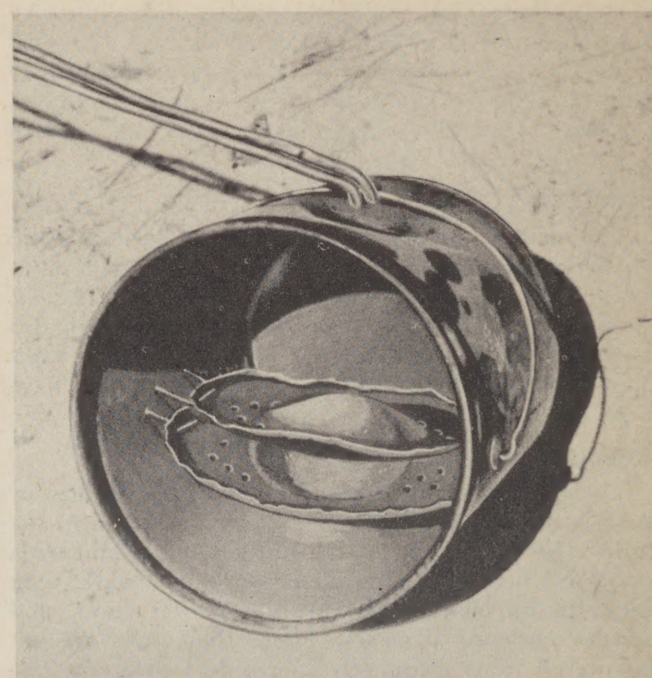

Figure 1—Flash Burner

Flash Burners

Flash burners are preferable to other types of waste oil burners because of simplicity of construction, availability of materials, and ease of maintenance. These units can be constructed in less than 2 hours from three 5-gallon pails and a foot of wire, using only a hammer, cold chisel, nails, and pliers.

1. PRINCIPLE.

When water is dropped on a hot plate simultaneously with oil, the steam produced vaporizes the oil. There is almost complete combustion of the oil. The result is an intense heat created with minimum expenditure of waste oil.

To insure the efficient operation of the flash burner, the flash plate must be kept hot continuously. This is done by constructing the flash plate carefully and by providing proper draught vents.

2. MATERIALS.

Cleaned waste oil
Oil reservoir, water reservoir (cans, drums, etc)
Galvanized iron pipe or aluminum tubing (with copper tubing nozzle) for fuel lines
Two shut-off valves for fuel regulation
Three round 5-gallon pails
Wire for securing flash plates

3. CONSTRUCTION.

a. FLASH PLATES.—Make the plates of the burner from the bottoms of two 5-gallon pails. Hammer out a central convex cone in the top plate and a central concavity in the lower plate. Rim the edges of the plates upward and punch nail holes as shown in figure 2.

b. HOUSING.—Cut two vents, each about 2 inches square, in a 5-gallon pail with one end removed. (See figure 3.)

Wire the top plate into position about 6 inches below the feed vent, with the central cone exactly under the vent. Wire the bottom plate 2 inches under the top plate, with the concavity directly under the cone of the top plate.

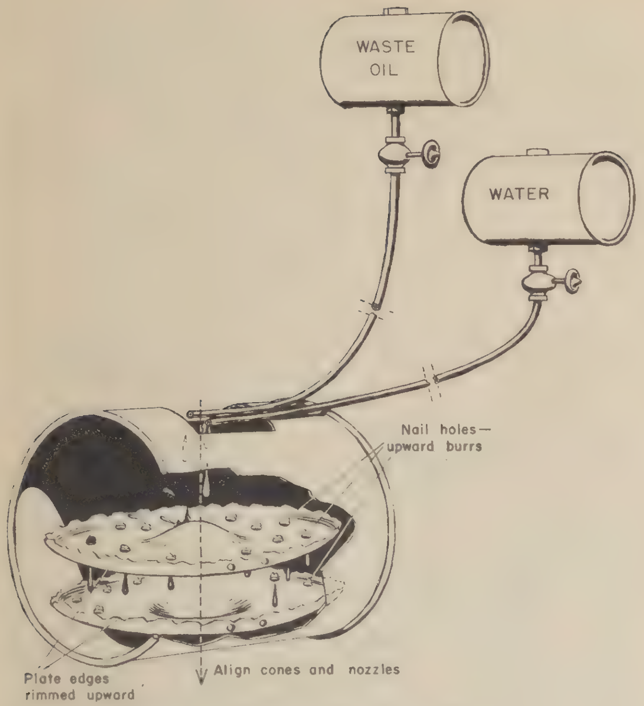

Figure 2—Flash Burner Assembly

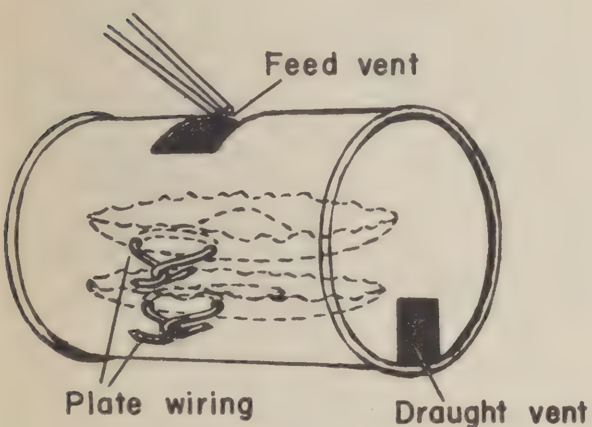

Figure 3—Construction of Housing

When the flash burner is assembled, the housing lies on its side with the flash plates parallel to the ground. (See figure 2.)

The flash burner principle can be adapted to an open-type heater without housing. (See figure 4.)

c. FUEL ASSEMBLY.—Fuel is fed to the burner by gravity. Construct fuel feed lines from galvanized pipe or from aluminum tubing. If aluminum tubing is used, attach short pieces of copper as drip nozzles at the feed vent, since aluminum will melt. Complete the fuel assembly with shut-off valves and reservoirs for water and waste oil.

4. OPERATION.

Insert a diesel oil-soaked rag through the draught vent and ignite. Regulate valve so that waste oil drips slowly on the top plate. The oil collects in the trough and drops through the perforations to the bottom plate, accumulating in the central depression. Any overflow burns in the bottom of the housing.

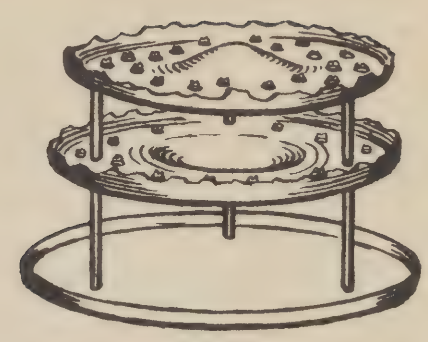

Figure 4—Open Flash Burner

Fire spreads from the burning rag to the oil pool on the bottom plate, which in turn heats the cone of the top flash plate. During this phase the oil burns briskly but with a dense black smoke. After about 5 minutes, regulate valve so that water drips *very slowly* on the heated top plate, where it flashes with a loud crackling noise. As the flash point of the oil is lowered, combustion becomes complete, the smoke decreases, and becomes white. Once the flash burner is running smoothly, feed the oil in a continuous small stream; feed the water in separate drops. Use about three times as much oil as water.

The draught draws the flames from the flash plates 2 or 3 feet into the apparatus to be heated. (See application of burners in other sections.) The heat can be varied by controlling the flow of oil. Between 1 and 2 gallons of cleaned waste oil are consumed per hour.

5. MAINTENANCE.

Except for occasional straightening of the flash plates, which become distorted by the heat, the flash burner requires almost no maintenance. Since waste oil is used for fuel, it is wise to clean the fuel lines occasionally.

Note

Do not attempt to preheat either the oil or the water in the flash burner system. The principle of the flash burner is entirely different from the oil vapor burner described following.

Oil Vapor Burners

1. PRINCIPLE.

Vaporized oil burns almost completely and with intense heat, saving fuel and keeping the camp area free of oily smoke. The oil burners described and illustrated utilize a pre-heating feature which causes vaporization of oil prior to burning.

The disadvantage of oil vapor burners is that they are difficult to maintain. For this reason flash burners usually are preferable to oil vapor burners.

a. PRE-HEATING.—Liquid oil is fed to the burner through a fuel line, one or more coils of which are exposed to and heated by the flames from the jets. Oil is vaporized in the pre-heating coils and reaches the jets as a hot vapor which burns almost completely. When the oil vapor burner is properly operated, a blow-torch effect is created at each jet. Because of the intense heat created, the entire heating element *must* be constructed of galvanized iron pipe.

b. BACK-SURGING.—To prevent back-surging of oil vapor into the feed line from the pre-heating coils, fuel may be fed by gravity from an elevated reservoir, or it can be force-fed from an air-pressurized reservoir. In either case, the shut-off valve which regulates the flow of fuel should be located as close as possible to the burner.

2. MATERIALS.

Cleaned waste oil or diesel oil
Oil drum for fuel tank
Galvanized iron pipe, $\frac{1}{2}$ or $\frac{3}{4}$ inch
Shut-off valve; pipe connections (elbows, tees, and plugs)
Air valve from salvaged tire or Mae West
Air pressure pump from vehicle, or 3-gallon decontaminating spray pump.

3. CONSTRUCTION.

a. HEATING UNIT.—Make the coils of galvanized iron pipe and pipe fittings. Locate the jet holes so that the flames are directed at the pre-heating coils. Make holes about $\frac{1}{32}$ inch in diameter with a punch or drill, or cut with a hacksaw. Holes drilled with a No. 54 drill are ideal. Limit the jet holes to five or six. Various types of oil vapor burner designs are shown in figure 5. Burner C has proved most effective.

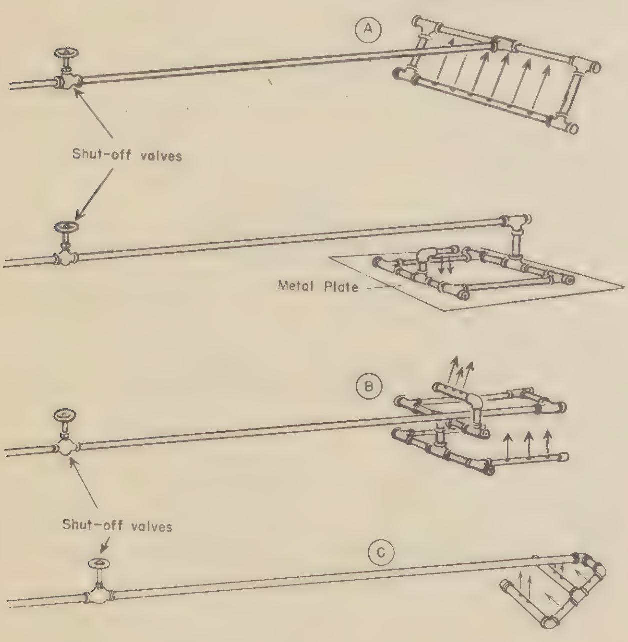

Figure 5—Oil Vapor Burners

b. SHUT-OFF VALVE.—Place the feed control valve within a few feet of the burner itself so as to minimize the back-surging of oil vapor in the burner and feed line.

c. RESERVOIR AND FUEL LINE.—Use a 55-gallon oil drum, or smaller, as a reservoir. Install it at least 36 inches higher than the burner. Fit the fuel line to the $\frac{3}{4}$ inch bung hole of the drum. Construct the fuel line from iron pipe. (See figure 6.)

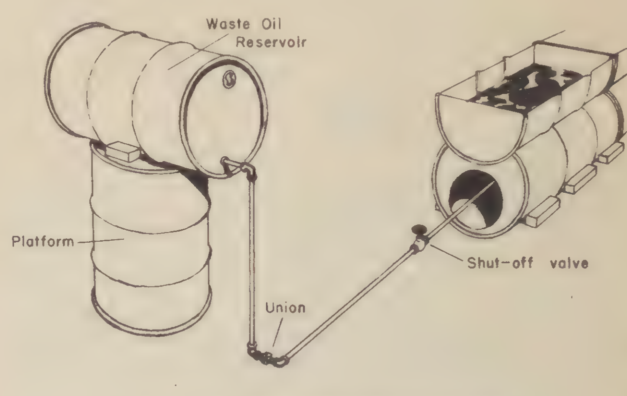

Figure 6—Reservoir and Fuel Line

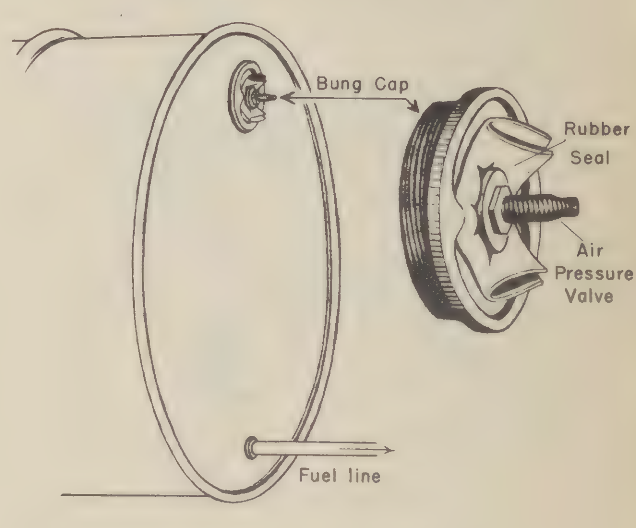

Figure 7—Force Feed

d. FORCE FEED.—Fit the 2-inch bung cap of the reservoir with an air valve from a Mae West or tire tube. Punch a small hole, insert the valve, and secure it by tightening a nut against a rubber sealing pad. (See figure 7.)

e. FUEL.—Burn waste oil or diesel oil in burners of $\frac{1}{2}$ or $\frac{3}{4}$-inch pipe. If diesel oil is burned, there is no need for a force-feed system.

4. OPERATION.

Build a small fire of grass or rags soaked in diesel oil around the burner. Add fuel from the burner slowly. A dense black smoke is produced. Once the coils

become hot, oil vaporization takes place. The vapor burns with a blowing sound and an almost white flame. Adjust the shut-off valve to give the smallest flow of fuel which will produce the maximum blow-torch effect. Too little flow of fuel will result in back-surging.

To force-feed fuel to the burner, pump a few pounds of air pressure into the fuel tank with a hand pump. About 5 pounds pressure is sufficient to insure a steady flow of fuel to the burner.

Burner A burns approximately 1 ½ gallons of waste oil per hour. Burners B and C burn 3 gallons of waste oil or 5 gallons of diesel oil per hour. (See figure 5.)

5. MAINTENANCE.

When waste oil is burned, a dense oil residue cake forms within the heating element unless the device is dismantled and cleaned daily. To have a burner available at all times, construct a second heating element for use while the other is being cleaned. If diesel oil is burned, only weekly cleaning is required. Burner C requires less maintenance than the other types.

It is best to make corner connections with tees and plugs rather than with elbows. When the various plugs are taken out, it is possible to ram a straight rod through all parts of the burner in succession, for removal of the cake.

Cleaning Of Waste Oil

Waste oil from airplanes and vehicles must be cleared of grit and water before being used in oil vapor burners. It is not as important to clean the oil used in flash burners, but it may serve to prevent clogging of the oil feed line at the shut-off valve.

WATER.—Water is heavier than oil and collects at the bottom of the waste oil container. Place the waste oil drum on its side on a suitable trestle support with the head or bung end of the drum raised 2 or 3 inches. This will allow only water-free oil to flow from the bung. (See figure 8.)

When waste oil is scarce, place the drum vertically, with the bung end down. After allowing several hours for the water to settle to the bottom, draw off the contents of the drum until the flow is free of water. Save the discarded watery oil until a drumful has been collected, and then repeat the separation process to recover oil from this mixture. In this manner very little usable oil will be wasted.

GRIT.—Remove grit from oil by straining through successive layers of burlap rags, fine screening, and coarse gravel.

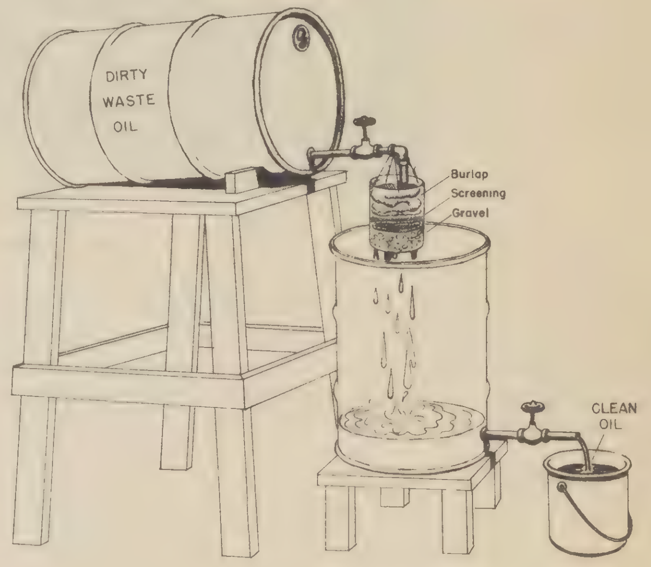

Figure 8—Cleaning Waste Oil

SECTION III

MESSKIT WASHING

The importance of proper messkit washing has been forcefully demonstrated by combat experience in all theaters. Outbreaks of diarrhea have been traced to inadequate cleaning of eating utensils. The following procedures, which differ from standard practice, are likely to reduce the incidence of intestinal disorders:

1. Messkits should be scalded in actively boiling water prior to every meal.
2. Following each meal, kits should be scraped clean into a garbage container, scrubbed in *two* separate containers of hot, soapy water, rinsed in *two* separate containers of clean boiling water, and air dried.

In many AAF installations the improvised messkit washing devices described below may be superior to the standard methods for the following reasons:

1. Water is brought to a boil more rapidly.
2. The fuel is easily available.
3. The messkit washers are located on the surface of the ground, rather than over a trench.
4. The fires are relatively smokeless.

Type "A" Unit

A generous supply of actively boiling water is the chief requirement for effective messkit washing. Boiling water is made readily available by the use of the flash burners or oil vapor burners described in

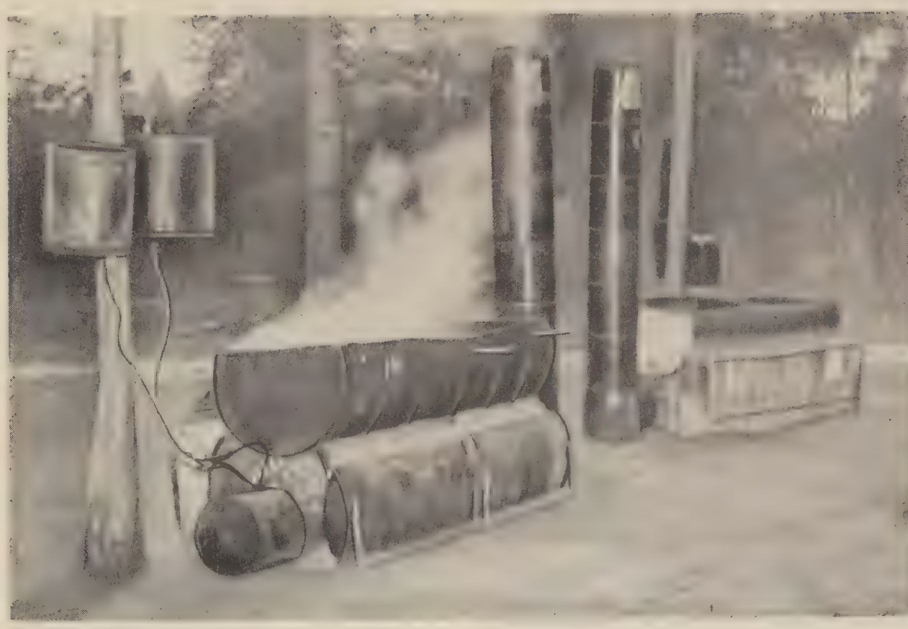

Figure 9—Messkit Washing Unit

Section II. A dependable messkit washing unit can be improvised which consists of two sets of water heaters, each heating two drums of water. Two drums of soapy water and two of rinse water are heated simultaneously. (See figure 11.)

1. MATERIALS.

Two flash burner or oil vapor burner assemblies
Eight 55-gallon oil drums
Sixteen 5-gallon round pails

2. CONSTRUCTION.

a. WATER CONTAINERS.—Cut four 55-gallon oil drums as shown in figure 10. Each water container holds about 35 gallons. Use two of these for soapy water; two for rinse water.

b. HOUSING.—Construct two sets of housings, one for heating the soapy water containers and one for heating the rinse water containers.

(1) Cut the drums as shown in figure 10 so that the water-containers can rest snugly in the housing.

(2) Cut 12-inch circular holes for the chimney and burner at opposite ends of the housing.

(3) Set the water containers into the housing; flatten and shape the projecting edges of the housing drums to make a smooth fit. (See figure 11.)

c. INSULATION.—To hold the heat within the housing, place clay, sand, cement, or sand-filled 5-gallon cans around the housing drums.

d. CHIMNEYS.—High chimneys are necessary to create a strong draught and to keep smoke out of men's faces. Stack at least six round 5-gallon open-

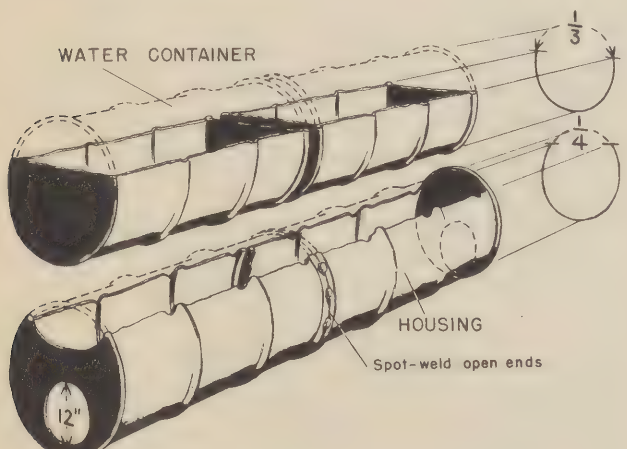

Figure 10—How To Cut Drums

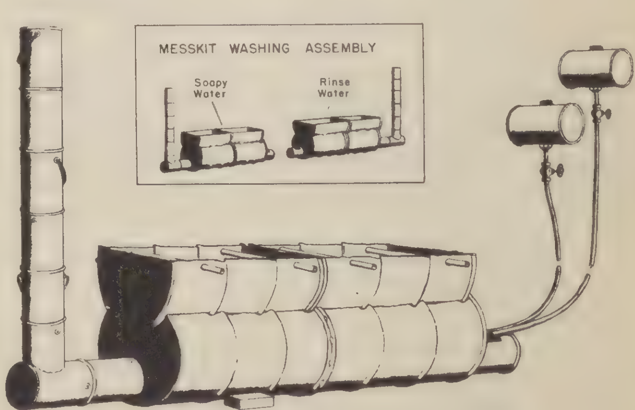

Figure 11—Construction of Messkit Washing Unit, Type A

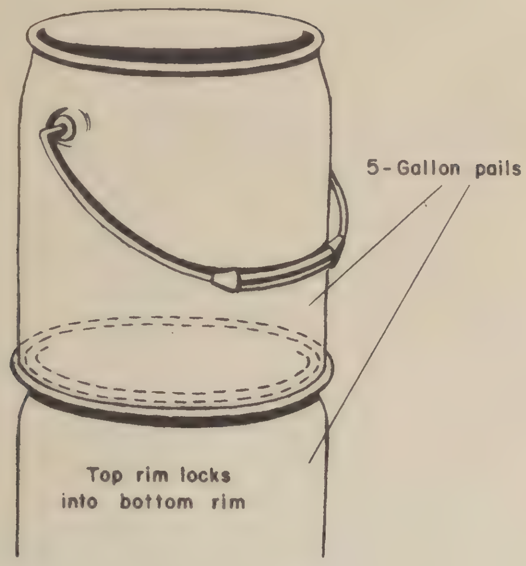

Figure 12—Chimney

ended pails for chimney. (See figure 12.) If rectangular 5-gallon cans are used, spot-weld them end to end.

e. INSTALLING BURNER.—Insert the open end of a flash burner securely into the circular opening in the housing. (See figure 13.) To insure the heating of both water containers at an approximately equal rate, place an open-ended 5-gallon round pail inside the housing, end to end with the flash burner; this directs the flames toward the farther container. If an oil vapor burner is used, insert it through the circular opening to rest under the first water container, and place a removable metal windshield against the opening.

3. OPERATION.

If the burners are properly operated, as described in Section II, the water in both drums should reach a rolling boil in 40 minutes. The water must be boiling

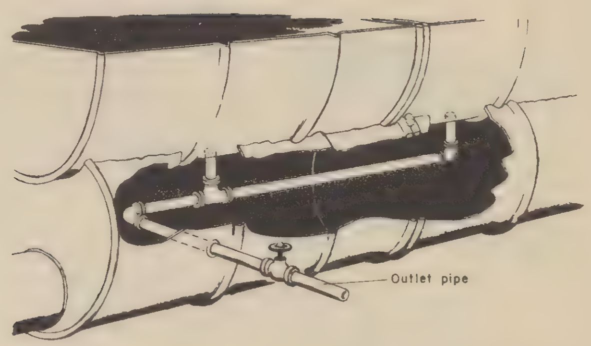

Figure 14—Drainage System for Water Containers

actively before the messkit washing line forms.

After use, allow the water to cool. Then drain it through an outlet pipe (figure 14), or lift and dump it into a grease-trapped soakage pit. After each meal, soap and scrub the water containers; then rinse them with fresh water.

Type "B" Unit

A simple unit can be improvised in which all four water containers are heated by one burner. (See figure 15.)

1. MATERIALS.

One open-type flash burner or oil vapor burner assembly

Three 55-gallon oil drums

Six 5-gallon round pails

2. CONSTRUCTION.

a. WATER CONTAINERS.—Cut two oil drums as shown in figure 16. Bend each drum open along line AB in order to form a pair of water containers.

b. HOUSING.—Cut one drum as diagrammed. Lay the two halves end to end, and spot-weld the ends together. Mound up dirt along the sides of the completed

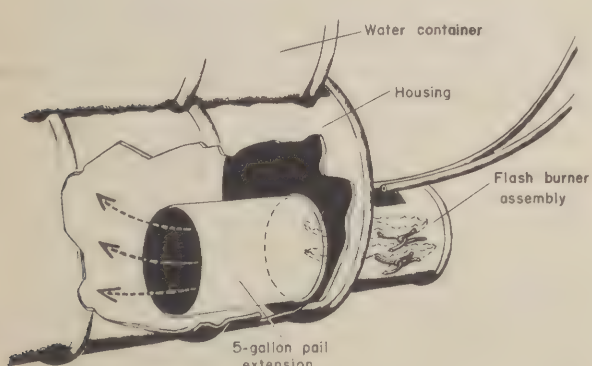

Figure 13—Installation of Burner

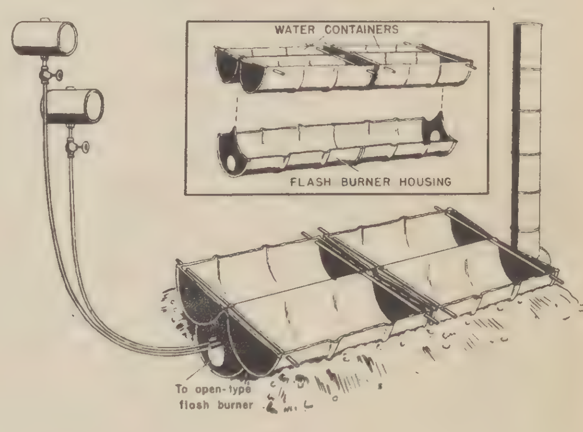

Figure 15—Messkit Washing Unit, Type B

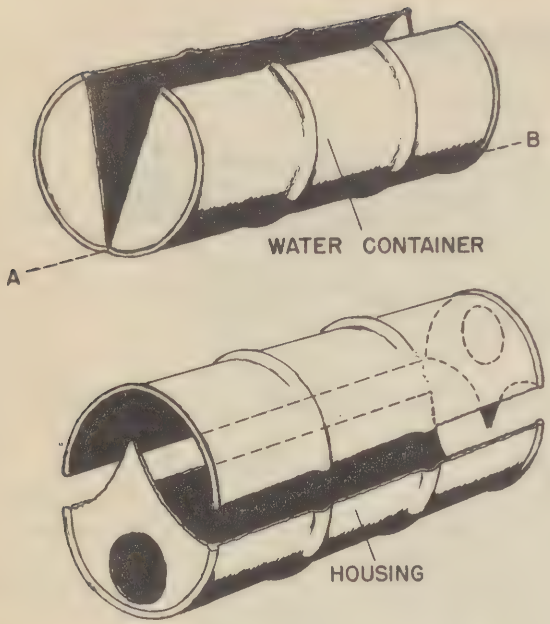

Figure 16—How To Cut Drums

housing, and fit the two pairs of water containers to the top of the housing.

c. CHIMNEY.—Stack at least six round 5-gallon open-ended pails for the chimney.

d. BURNER.—Place an open-type flash burner through the opening in the front end of the housing; set it under the first pair of water containers. Lead in the fuel lines and drip nozzles, and make a removable door as a windshield.

If an oil vapor burner is used, it can be moved backward and forward in the housing to heat the water containers uniformly. Burner C (figure 5) is most effective.

3. OPERATION.

The water in all four containers will reach the boiling point in an hour if the flash burner is used, or in 45 minutes if the oil vapor burner is used.

After messkit washing, allow the water to cool. Lift and dump the water into a grease-trapped soakage pit. After each meal, soap and scrub the water containers; then rinse them with fresh water.

SECTION IV

GARBAGE DISPOSAL

Proper disposal of garbage is one of the most important measures for eliminating fly breeding and diarrheal diseases.

Garbage may be disposed of by burial, burning, sale or gift, or by dumping at sea.

In areas with a low water table, *burial* is the best disposal method. In high water table areas, burial pits and digestion pits are unsuitable because they become filled with water, especially during monsoons.

Disposal of garbage by *burning* should be confined to units of 300 men or less. When fuel wood is available, the standard inclined plane incinerator is the preferred type. When fuel wood cannot be depended upon, incinerators utilizing waste oil burners are practical and simple to construct. Large scale incineration is impractical in combat areas.

In certain areas, notably in India, a large part of the garbage is disposed of by human and animal *scavengers.* Garbage thus becomes strewn over a wide area, creating a nuisance and a fly-breeding problem. Dumping garbage for collection by scavengers is an unsatisfactory disposal method. The sale of garbage to contractors is uncommon in overseas zones.

On small islands or in coastal areas, the best method of disposal is to *dump* the garbage three miles out *at sea,* with due regard for prevailing winds and currents. This method demands the use of a garbage truck and scow, and of a dock which will support the truck Until these facilities are available, it is advisable to dump the garbage on the beach at mid-outgoing tide, on the leeward side of the island. While changing tides and damage to the dumptruck from salt water present certain problems, they are less serious than the practical difficulties of incineration or burial in these small islands.

When using the burial or incineration methods of disposal it is essential to separate liquids from solid garbage. A screen or burlap strainer can be used for this purpose, or a G.I. can with a perforated bottom. The strained liquid is then disposed of by methods discussed in Section V, Liquid Waste Disposal, and the solid garbage by the practical improvised methods described following.

Sanitary Fill

Burial of garbage by the sanitary fill method ordinarily is a large-scale operation for accommodating the garbage of 10,000 men or more per day. It requires the use of dumptrucks, draglines and bulldozers. However, the same method can be adapted to dispose of the garbage of 50 to 400 men.

Disposal by sanitary fill is practical where (1) the level of sub-surface water never rises above 8 feet from ground level, (2) the soil is soft enough to be shoveled,

and (3) the soil porosity is sufficient to prevent collection of rain water.

1. PRINCIPLE.

An initial trench is dug, and the dirt is piled at one side to serve as a ramp. Solid garbage is dumped each day over the ramp into the trench, gradually filling the trench. Each day's dumping is covered with dirt dug from an adjacent trench. When the first trench has been filled, the trench which supplied the covering dirt will be ready to receive garbage. (See figure 17.)

The dumped garbage must be packed down as hard as possible and covered each day with at least 2 feet of *hard-packed earth* as a seal against flies and rodents. Liquid garbage must not be dumped in a sanitary fill area.

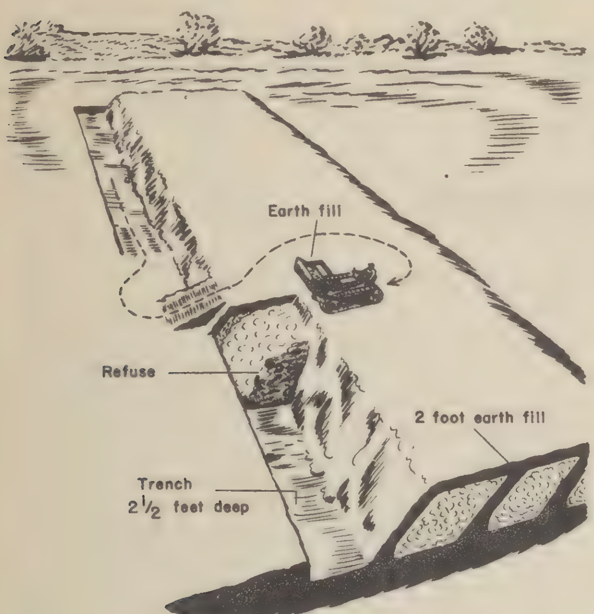

Figure 17—Large Scale Sanitary Fill

2. SMALL SCALE OPERATION.

A practical sanitary fill area which will accommodate the garbage of an AAF unit of approximately 300 men is shown in figure 18. Dig the first trench 3-feet wide, 3-feet deep and about 8-feet long. Dump garbage at one end and pack down with shovels or weighted wood tampers. Remove earth from the other end of the trench to cover the day's garbage. Pack it down 2 feet deep over the garbage. Also seal off the exposed end of each day's garbage pile with two feet of *hard-packed* earth. Each day, fill the trench at one end with garbage and extend it at the other end to furnish earth cover for the garbage.

As an additional precaution for preventing fly breeding, spray each dumping of garbage with sodium arsenite (1:100) before sealing off with packed earth. Waste oil or creosote may also be used.

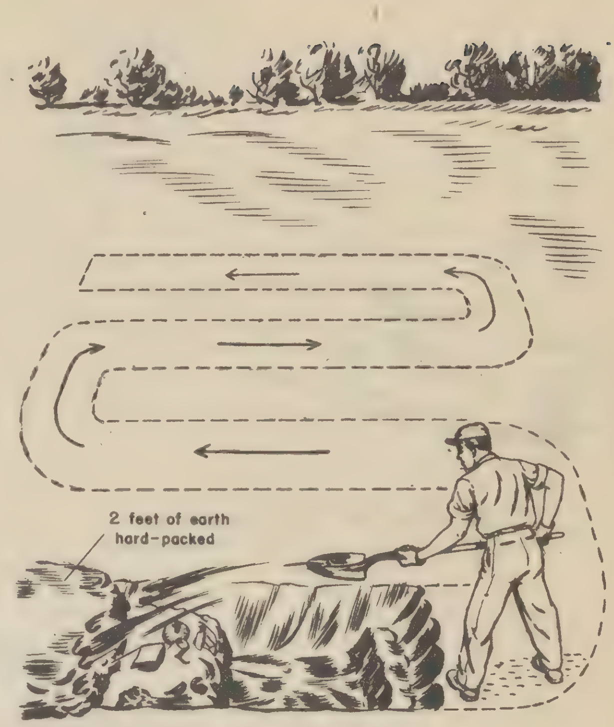

Figure 18—Small Scale Sanitary Fill

Flash Burner Incinerator

A small incinerator heated with a flash burner can dispose of the garbage of at least 300 men per day. The burner uses about 1½ gallons of waste oil per hour and needs little attention during operation. (See figure 19.)

1. MATERIALS.

Eight 5-gallon round pails
Two 55-gallon oil drums
One flash burner assembly (See Section II.)

2. CONSTRUCTION.

a. Cut two circular openings in the ends of a 55-gallon oil drum. The flash burner fits into one; the chimney into the other.

b. Cut a pie-shaped opening in the chimney end of the drum through which to rake the burned ash. Make a sheet metal door for this opening.

c. Cut a large rectangular opening in the drum through which to load the garbage. Flatten the cut-away metal and insert it in the drum for use as the incinerating plate.

d. Run a supporting pipe transversely through the drum at the burner end, to hold the incinerating plate about four inches off the bottom of the incinerator. This puts the higher end of the plate opposite the flash burner and permits the flames to pass both below and above the incinerating plate. The lower end rests

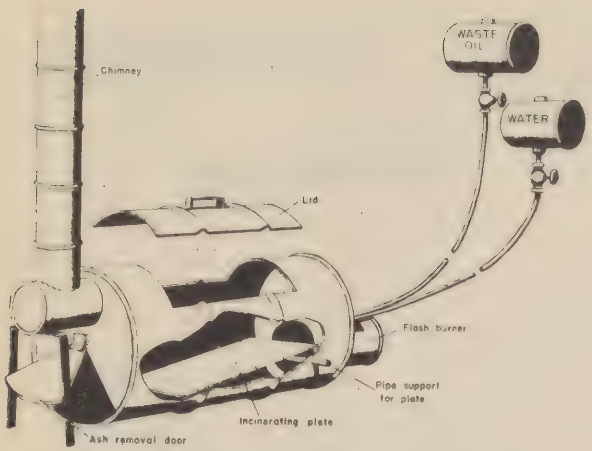

Figure 19—Flash Burner Incinerator

directly on the bottom of the incinerating drum.

e. Cut a lid for the incinerator from a second drum, large enough to overlap the opening. Bolt on a sheet metal handle.

3. OPERATION.

About 5 gallons of solid, strained garbage are incinerated at one time. Waste oil added to the garbage may aid incineration. Add new loads of garbage as soon as the garbage in the incinerator becomes dry. Push the dried garbage down the plate to make room for the new charge of wet garbage. When the dried garbage has burned to ash, rake it out the door at the end of the drum.

If this incinerator is operated continuously during the daylight hours, about 60 gallons of garbage can be incinerated, or approximately the amount accumulated daily from a unit of 300 men.

SECTION V

LIQUID WASTE DISPOSAL

The usefulness of soakage pits and soakage trenches may be greatly limited by any of four factors: permanent ground frost, heavy rainfall, high water table, or poor soil drainage. Dumping of liquid waste at sea is a solution applicable to only a limited number of AAF installations. If liquid waste is dumped into rivers, it must be clarified first with chemicals. Incineration of liquid waste usually is impractical.

The difficulties of disposing of liquid waste in the tropics make it essential to apply all current methods in the most efficient manner.

Grease Trap

Previous to disposal of the waste water by soakage, evaporation, or chemical treatment, every effort must be made to separate fats and soap from liquid waste thoroughly. This is done by means of a grease trap. The efficiency of grease traps may be increased by the following measures:

1. Do not pour hot waste water into a grease trap. Allow the waste water to cool as much as possible.
2. Keep the grease trap as cool as possible. Various cooling methods may be used: place the trap in a shaded location; settle it as far as possible into the earth to catch the underground coolness; or wrap it in continually moistened burlap for evaporative cooling.
3. Strain out particles from the waste water before emptying it into the grease trap. Improvise a strainer by perforating the bottom of a pail or gasoline can and filling the container with coarse material such as gravel, burlap, toweling, straw or grass. Burn the straining material or bury it daily.
4. Keep the flow of water within the trap as slow as possible. To insure a slow flow, wooden traps should be long, narrow and deep, and the waste water should be poured in slowly. Baffle plates may be added to cut down the rate of flow further.
5. The size of grease trap used depends upon the amount of waste water to be cleared. For liquid kitchen waste, the peak load is approximately 1½ gallons per hour for each man. This amount of waste water will be cleared of its fats and soap by approximately an equal volume of water in the grease trap. Field experience proves that for a mess of 50 men, a grease trap of about 75 gallons must be provided; for 150 men, a 225 gallon trap is required. A grease trap larger than 300 gallons is impractical.
6. Several small grease traps are preferable to one large one. Traps should be connected in series, not in parallel.
7. The addition of hydrated lime to the grease trap water will aid in curdling fats and soap.

Siphon Grease Trap

An effective cold water grease trap can be improvised from salvaged oil drums and pipe connections. (See figure 20.) Drums containing about 45 gallons of water can be connected in series to give the necessary volume of water for maximum separation of fats and soap from waste water.

1. MATERIALS.

Oil drums, 55-gallon
Pipe and pipe connections
Gravel
Burlap
Screening

2. CONSTRUCTION.

a. DRUMS.—The number of clean 55-gallon oil drums used depends upon the size of the mess. Thread pipe into the $\frac{3}{4}$-inch bung of each drum as shown in figure 20. Place the drums in series so that each drum is slightly lower than the preceding drum; the last drum is set almost entirely into the ground. The outlet siphon of the last drum drains into the soakage pit. Cut the top from each drum, leaving the rolled edge intact.

b. STRAINER.—Fasten a piece of burlap loosely over the opening of the first drum, and fill the depression with coarse filtering material, such as straw, grass, or gravel.

c. SCREENS.—Cover the remaining drums with burlap, fastened fairly tightly. If these drums are sprayed weekly with waste oil to prevent fly breeding, no burlap covers are needed.

3. OPERATION.

Fill the drums with water, letting the overflow run into the soakage pit.

Dispose of the liquid waste in small portions rather than all at once after each mess. Pour the waste slowly into the strainer to take out the larger particles and soap curds. On contact with the water in the oil drum, the fats and soap solidify and rise to the surface. The cleaned waste water flows from the bottom of the drum to the top of the next drum in the series. The fats which fail to separate out in the first drum rise to the upper surface of the succeeding drums of water. The water which finally flows into the soakage pit should be almost completely clear.

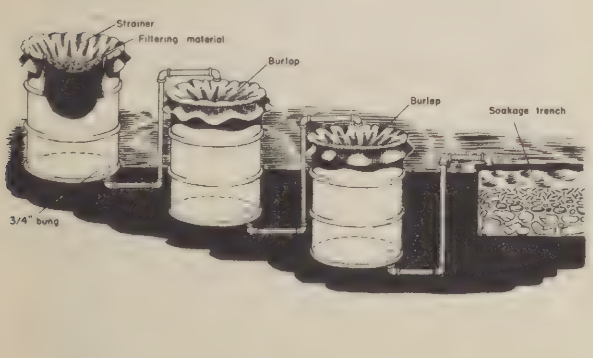

Figure 20—Siphon Grease Trap

4. MAINTENANCE.

Skim off the solidified greases in all drums daily. Bury or burn the grease. Disconnect and clean the drums with soap each month.

Soakage Pits

Soakage pits act as reservoirs from which water is gradually absorbed by the surrounding ground. Their effectiveness depends upon the clearness of the water poured into the pit, the height of the ground water table, the porosity of the soil, and the extent of soakage surface. In terrain of rapid soil drainage, such as limestone or coral, small pits will function for long periods of time. In slow-draining silty or clayey plains, pits must be much larger. Great care must be taken in slow drainage areas to clear the waste water thoroughly before running it into a soakage pit. (See figure 20.)

In areas of poor soil drainage, apply the following practical measures:

1. Build soakage pits or trenches at the brow of a hill, so that shallow underground drains may carry off the overflow into a stream or down a ravine. (See figure 21.)

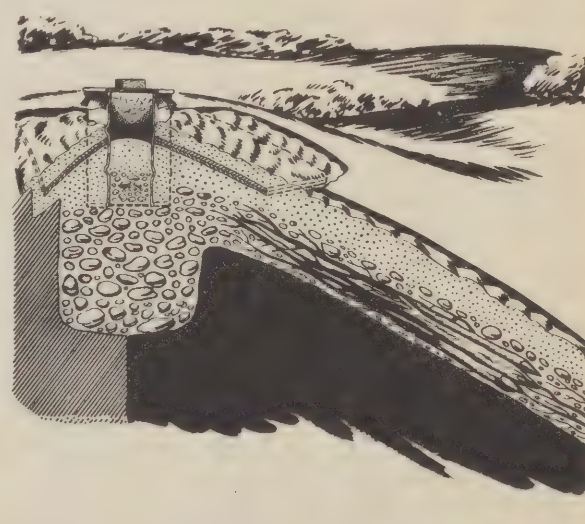

Figure 21—Hillside Soakage Pit and Underground Drain

2. In high water table areas, construct a series of long shallow trenches with shallow underground drains to carry off the overflow into a river. Fill the trenches with crushed cans, small timbers, charcoal, gravel, rock, or other filtering materials. (See figure 22.)

3. The soakage surface of a pit depends upon its

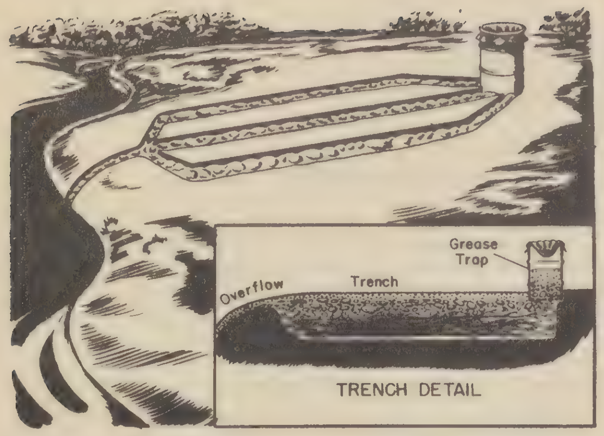

Figure 22—Soakage Trenches for High Water Table Areas

shape. The goal is to obtain the maximum soakage surface per volume of earth shoveled. A cube-shaped pit, 4 x 4 x 4 feet, gives a soakage surface of 80 square feet with removal of 64 cubic feet of earth. An oblong pit, 2 x 4 x 8 feet, also with a volume of 64 cubic feet, gives a soakage surface of 96 square feet, an increase of 16 square feet over the 4-foot cube.

4. To prevent the accumulation of fumes, ventilate soakage pits by means of shafts inserted close to the pit bottom and perforated throughout their length. Improvise shafts from materials such as iron or bamboo pipe, sheet metal, cans, shell cases, or bomb cases. A rod inserted through one of these shafts can be used to check on the variation in water level within the pit. The exposed ends of the vents should be screened.
5. It is advisable to have more than one soakage system. As soon as one system begins to lose its power of absorption, it should lie idle for three or four weeks. By alternating in this manner, pits or trenches may be kept useful for an increased period of time.
6. Charcoal is an effective filter for soakage systems. Fill the pit with crossed layers of small saplings, installing at least four large pipes as air-vents. Douse the saplings thoroughly with waste oil, and cover the pit with logs and dirt. Pour a few gallons of kerosene into the vents and ignite. The contents of the pit will burn, leaving a charcoal coating on the surface of the saplings.

Evaporation Beds

Where the ground surface is rocklike and non-porous, soakage pits and trenches are difficult to construct and will function only a short time. In such areas, if the climate is hot and dry, waste water can be disposed of satisfactorily by evaporation beds. Evaporation beds operate partially by evaporation but also by soil absorption and by oxidation of the waste. In order not to clog the beds, the waste water must be thoroughly pre-treated by efficient grease-trapping.

1. CONSTRUCTION.

To determine the size of the beds, allow 3 square feet per man for kitchen waste water and 2 square feet per man for bath waste. Divide the total area by seven, and construct the beds in individual units, one for each day of the week. Place the beds so that the waste can be channeled to any particular bed as desired. (See figure 23.)

Construct the beds by scraping off the top soil and piling up a small dyke around each one. Then spade each bed to a depth of 10 to 15 inches, and rake the surface into a series of ridges and depressions. The ridges should rise about 6 inches above the depressions.

2. OPERATION.

Flood the first bed to the top of the ridges and allow the water to percolate and evaporate for two or more days. Flood the other beds on successive days. After drying, respade and reform each bed. The cycle for each bed is: flood on first day, allow to evaporate on second and third days, and respade on fourth or fifth day.

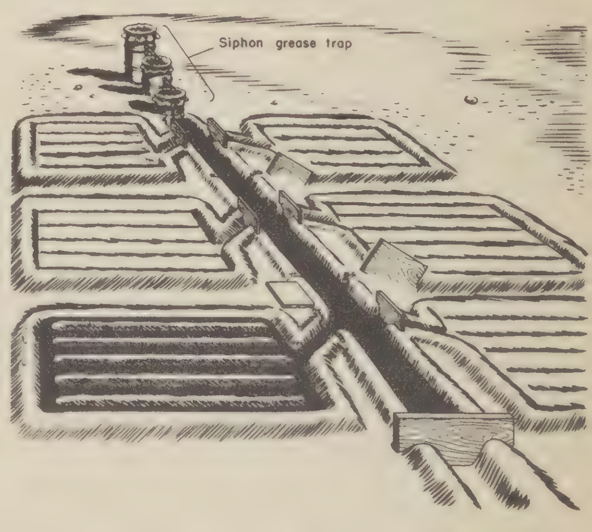

Figure 23—Evaporation Beds

Chemical Clarification

In terrain with a high water table, poor soil drainage, and high humidity, clearing of waste water by chemical treatment may be the best disposal method. The chemicals cause fats and soap to settle to the bottom of a settling tank. The cleared water is then run off into a stream. The procedure is as follows:

1. Pass the waste water through a grease trap into a settling tank.
2. Prepare separate solutions of alum and of soda ash in pails. The amount needed for clearing

waste water is about 10 times the amount stated in the table in Section X, Water Supply and Purification. (Hydrated lime may be used instead of soda ash.)

3. Add the alum solution and mix thoroughly with the waste water. Then mix in the soda ash (or lime) thoroughly. A heavy chemical compound (floc) is formed which settles to the bottom of the tank, carrying suspended particles of fat with it.
4. Complete settling should take place in 1 to 3 hours. Pump off the cleared water on top, or allow it to run out through a suitably placed outlet. Drain this water into a stream bed.
5. Allow the floc in the bottom of the tank to accumulate until its level reaches the clear water outlet. Then drain this sediment through an outlet at the bottom of the tank, and clean the tank. Unless it is treated and removed, the accumulated sludge will become offensive. Oil this sludge and bury it in a small-scale sanitary fill area. (See figure 18.)

SECTION VI

HUMAN WASTE DISPOSAL

In combat areas, dysentery and common diarrhea cause more loss of time than any other disease. Proper disposal of human waste is one of the chief means of preventing diarrheal diseases.

Prescribed methods for human waste disposal are not always practicable in forward areas. For example, in many areas, heavy rainfall and high water tables cause rapid flooding of deep pit and bored-hole latrines, floating the contents to the surface of the ground. This not only creates a fly-breeding hazard but permits feces-carrying flies to contaminate food readily.

While shallow trench latrines may be used in semipermanent bases, large numbers will be required because of rapid filling. Another disadvantage is that the trenches are easily flooded.

Mounded pit latrines, common in India, require considerable labor to move large quantities of dirt. A mosquito-breeding problem also may be created in the borrow pits.

At coastal bases it may be feasible to construct oversea latrines. However, this method is practicable only for the few men living nearest the water and is rarely useful for large groups.

The ideal latrine is fly- and mosquito-proof; it functions on top of the ground, rather than under it; and the method of waste disposal is simple without being distasteful to the latrine detail. The following improvised devices meet these conditions, not only for the wet tropics, but for any other area.

Oil Drum Latrines

Effective latrines can be readily constructed from discarded oil drums. Such latrines can easily be made flyproof. Portable shelters may be constructed over them to afford protection against mosquitoes, rain, and sunlight. In areas of rapid soil drainage the drums can be set into the ground over a soakage pit. In areas where the water table is high, the drums can rest on the surface. The contents of the drums either can be burned out daily or the entire drum can be set into a suitable incinerating device.

Drum Latrine With Flue

1. CONSTRUCTION.

The simple improvised latrine (figure 24) is designed so that the drum itself can be burned out daily without removing it from its site. It is a practical device for use in areas where waste oil is plentiful. Use an open-ended 55-gallon oil drum. Fit flue about a foot from the bottom of the drum. Construct a removable sturdy flyproof wood seat with a self-closing lid to fit

Figure 24—Drum Latrine

securely over the head of the drum. Set the latrine into the ground or raise a foot rest in front of the drum, to support the weight of the user's legs.

If the area drains rapidly, perforate the bottom of the latrine drum and set it down into a *flyproofed* soakage pit. (See figure 25.) This will drain the drum of urine and facilitate burning out by oil.

2. OPERATION.

Remove the portable shelter and wood seats daily, and pour about 5 gallons of waste oil over the feces. Ignite the oil with a burning diesel oil-soaked rag. Complete burning of the contents will be accomplished in about an hour, or less if the urine has been drained into a soakage pit. The flue serves as an air intake and promotes combustion.

Provide one drum latrine for every 12 men. Locate the drums near flight lines and sleeping quarters.

CAUTION

1. Never burn out a latrine with gasoline.
2. Smoking in vicinity of drum latrines must be prohibited—post signs.

These rules are important—they will prevent dangerous explosions and injury from burns.

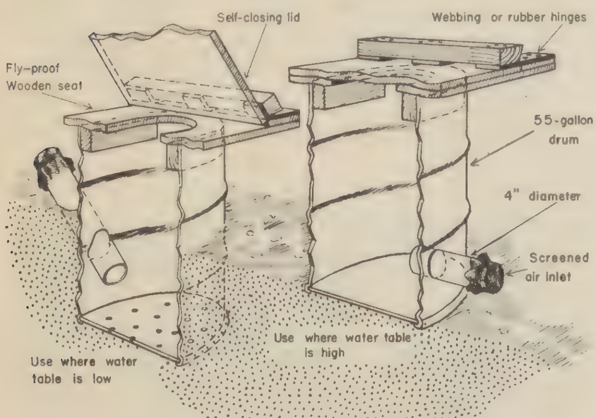

Figure 25—Construction of Oil Drum Latrines

Latrine And Incinerator

This type of improvised latrine makes use of a separate incinerator device. The complete assembly consists of (1) a flyproof drum latrine and (2) a latrine incinerator. It provides a simple and not objectionable means for effecting flyproof human waste disposal in all types of terrain and climate.

1. FLYPROOF LATRINE DRUM.

Use an open 35-gallon drum for the collection of feces. Drive a dozen or more holes through the upper half of this drum; leave the bottom half unperforated.

Place the 35-gallon drum inside a 55-gallon drum

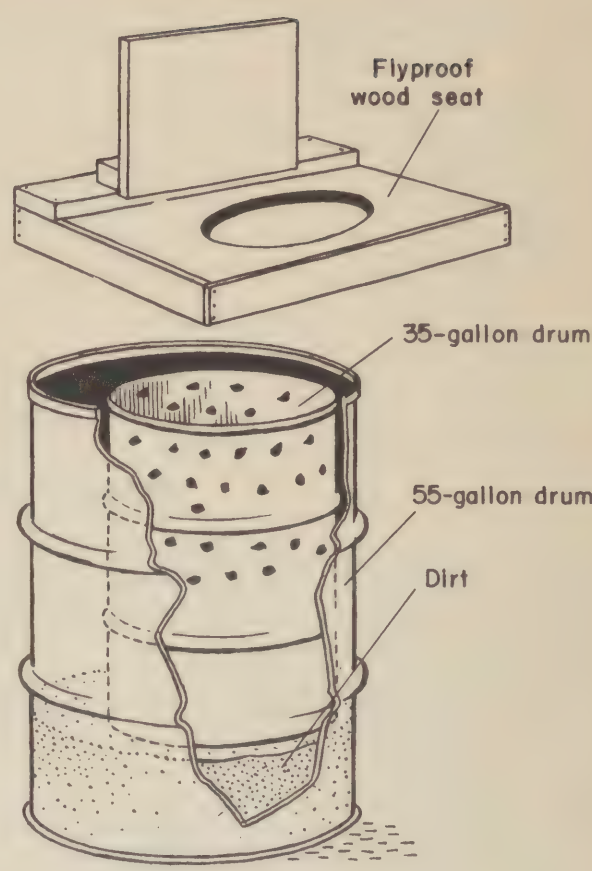

Figure 26—Flyproof Latrine Drum

filled with about eight inches of dirt. The tops of the inner and outer drums should come to the same level. The outside drum, when fitted with a sturdy removable flyproof wooden seat with a self-closing lid, acts as a sealed flyproof container for the inner drum. (See figure 26.)

2. INCINERATOR.

a. HOUSING.—An open-ended 55-gallon drum houses the burner and is designed to accommodate the 35-gallon latrine drum. To support the latrine drum during incineration, place pipes or rods through the housing twelve inches from the bottom. When in position for incineration, the top of the latrine drum should sit about 4 inches higher than the top of the housing. (See figure 27.)

b. CHIMNEY.—The chimney is composed of two parts. Make the lower part from half of a 55-gallon drum so that it fits over the latrine drum, and rests on the top rim of the housing. An airtight joint is unnecessary. Construct the upper part of the chimney from three round open-ended 5-gallon pails. Wire the chimney stack securely to the half-drum, and provide pipe or rod handles for lifting the chimney assembly.

c. BURNER.—Place a simple oil vapor burner, or flash burner, within the housing. For the construction of the burner, see Heating Devices, Section II.

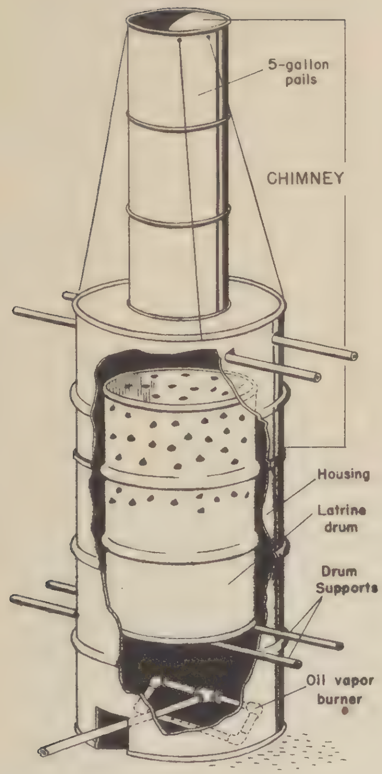

Figure 27—Incinerator

3. OPERATION.

Pour 3 or more gallons of waste oil into the feces in the 35-gallon drum latrine. Then lift the latrine drum out of its container and place it inside the incinerator housing. Set the chimney on the housing. (See figure 28.) Now start the burner. The flames will envelop the 35-gallon drum and ignite the oil poured into the feces.

The feces of 75 men can be burned to a powder in less than 1 ½ hours. No odor is produced during incineration. A 35-gallon drum will be about one-quarter filled by 75 men daily. One incinerator will easily handle the waste of 300 men per day.

Figure 28—Operation of Incinerator

SECTION VII

SHOWERS AND WASHING FACILITIES

Devices which provide hot water for showers, shaving and hand-washing can be easily improvised. Where hot water is unnecessary for showers, the decontaminating apparatus (M3A1 or M4) can readily be converted for use as a shower.

Utility Hot Water Heater

For this purpose a simple small water heating device may be improvised, using a flash burner. (See figure 29.)

1. MATERIALS.

- 35-gallon oil drum
- 55-gallon oil drum
- Flash burner
- Two 3-foot pipes or rods
- Six 1-gallon oil cans

2. CONSTRUCTION.

a. HOUSING.—Cut away the upper third of a 55-gallon oil drum. Place the drum with the open end up. Cut a circular opening at the bottom of the drum into which the flash burner can be inserted.

Install two horizontal support pipes or rods in the housing, about 3 inches above the top flash plate. These support the water container.

b. WATER CONTAINER.—Remove the two bung caps from a cleaned 35-gallon oil drum. Through the 2-inch bung insert a 1 ½-inch pipe, about 20 inches in length. Keep this pipe a few inches off the bottom of the container by a pipe collar fitted at the upper end of the pipe. Insert a cone of sheet metal for use as an intake funnel at the mouth of the pipe.

Insert a ¾-inch pipe into the smaller bung as the water outlet. This pipe should not extend into the drum.

c. CHIMNEY.—Spot-weld about six open-ended 1-gallon oil cans end-to-end to serve as a chimney. (Sheet metal or shell cases also can be made into a

chimney.) Insert the chimney 3 or 4 inches into the housing.

Place the assembly on its side. Fill the spaces between the housing, chimney, and water container with a 3- or 4-inch layer of firm cement.

3. OPERATION.

Fill the water container through the funnel. Start the flash burner and allow about 20 minutes for the water to heat.

To draw hot water for shaving or hand-washing, pour cold water into the funnel. The cold water running to the bottom of the container displaces an equal amount of hot water at the outlet.

Locate water heaters convenient to the kitchen and to the living quarters.

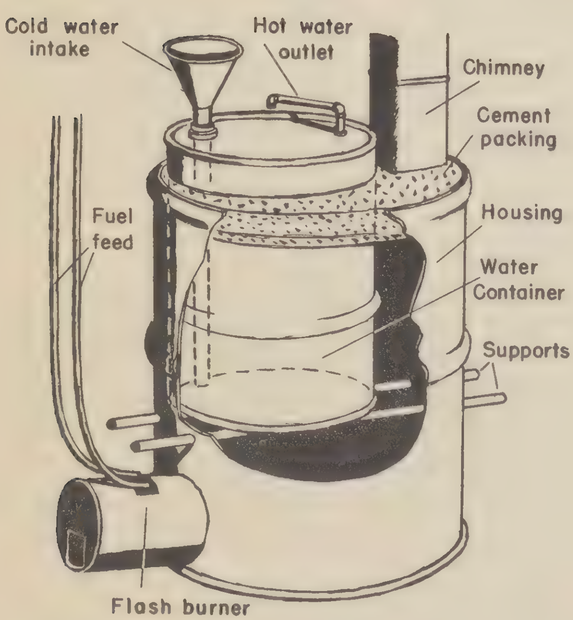

Figure 29—Utility Hot Water Heater

Hot Water Shower
(Steam Type)

An effective hot water shower using live steam may be improvised. (See figure 30.)

1. MATERIALS.

Flash burner
Four 55-gallon oil drums
Six 5-gallon round pails
30 feet of ¾-inch pipe
¾-inch pipe connections
Two shut-off valves
Fuel transfer pump (hand-operated)

2. CONSTRUCTION.

a. STEAM DRUM.—Support a cleaned 55-gallon oil drum in an upright position over a flash burner. House the burner, steam drum and chimney as illustrated in figure 30.

b. STEAM OUTLET.—Install a ¾-inch outlet pipe in the small bung of the steam drum. Use a straight length of pipe that angles only at the entrance to the overhead hot water drum. No shut-off valve is needed in this line.

c. OVERHEAD WATER DRUMS.—Mount two open-ended cleaned 55-gallon oil drums on a trestle about 10 feet off the ground. One drum serves as a source of heated water; the other, of cold water.

d. PIPE CONNECTIONS.—Thread ¾-inch pipe between the two small bungs at the bottoms of the overhead drums. In the inside of the hot water drum install a check valve at "A." Any flapper valve, such as the metal flapper at the top of an oxygen walk-around bottle, is suitable for this purpose. This pipeline and

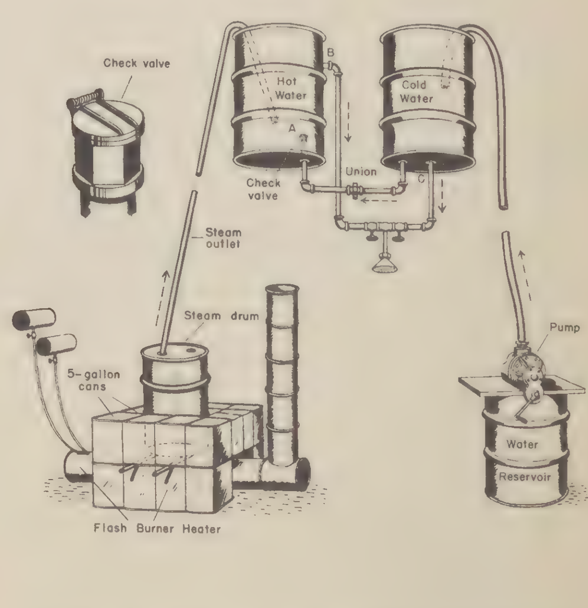

Figure 30—Steam Type Hot Water Shower System

valve allow water to flow from the cold drum into the hot drum, but not in the reverse direction.

Weld two pipe flanges into the drums at "B" and "C", and install pipes which conduct water from the two drums to the shower head.

e. SHOWER HEAD.—If a regular shower head is unobtainable, improvise a substitute from a No. 10 can by perforating the bottom and welding the can to the shower outlet pipe.

f. WATER SUPPLY.—Use one or more open-ended 55-gallon oil drums at ground level as water reservoirs. Place a hand-operated fuel transfer pump on the lip of one of these drums. Fifty-five gallons of water can be pumped to the overhead cold water drum in 3 minutes. Cover the tops of these water reservoirs.

3. OPERATION.

Pump water into the overhead drums from the reservoir. As the water level rises in the cold water drum, water flows through the connecting pipe to the hot water drum. Fill both drums to the top in this manner.

Pour about 15 gallons of water into the steam drum through the large bung hole. Then tighten the bung cap.

After the flash burner is started, the steam generated at ground level heats the water in the overhead hot water drum to an active boil in about 1 hour.

Because of the level of the hot water outlet ("B", figure 30), one man can use only 15 gallons of hot water at a time. If the overhead supply is restored by pumping water from the reservoir, the shower can be operated continuously.

Carefully remove the 2-inch bung cap from the steam drum immediately after shutting off the burner. This prevents sucking water down from the overhead drum into the steam drum as it cools.

Hot Water Shower
(Convection Type)

1. MATERIALS.

One flash burner
Three 55-gallon oil drums
One 16-gallon drum
30 feet of ¾-inch pipe
¾-inch pipe connections
Five 5-gallon round pails

2. CONSTRUCTION.

a. HOUSING.—Cut the end from a 55-gallon drum and save the metal. Construct a chimney of stacked open-ended 5-gallon round pails; insert the chimney into one end of the housing as illustrated in figure 31.

b. WATER HEATER.—Place a small drum within the housing on two rod supports. Cut two holes through the housing and the water heater drum and weld two pipes in position to the water heater at "A" and "B".

c. FLASH BURNER.—Fit a flash burner into the cut-away metal end of the drum and insert the burner and shield into the drum. (See Section II.)

d. INSULATION.—Cover the housing with dirt, clay, or cement insulation, to retain the heat.

e. OVERHEAD DRUMS.—Place two drums on an overhead support. Fit the pipe connections as shown in figure 31.

3. OPERATION.

Fill both overhead drums with water as in the steam shower shown in figure 30. This automatically fills the water heater.

The flash burner heats the water in the water heater. By convection, the hot water rises to the overhead hot water drum and is replaced by cold water from above. A continuous circuit of heated water is thus established.

Water is brought to 190° F in the overhead drum in 75 minutes.

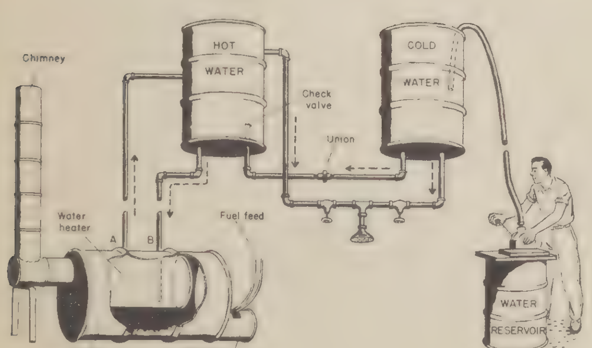

Figure 31—Convection Type Hot Water Shower System

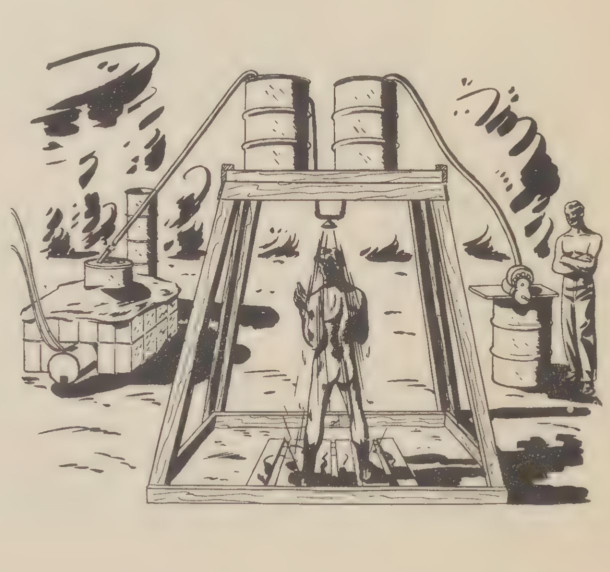

Figure 32—Overhead Shower

SECTION VIII

LAUNDRY

Since AAF units in forward areas usually are separated from QMC laundry units, installations must be improvised to enable the men to wash their own clothes. Native laundry work in the tropics may be hazardous because of the possible transmission of fungous diseases and skin infections.

AAF squadrons should have four or more laundry set-ups located convenient to living quarters. Each set-up should consist of a reservoir of clean water, facilities for heating water, scrubbing tables or improvised washing machines, and a means of disposal of soapy and rinse water. (See figure 33.)

Figure 33—Complete Laundry Unit

WATER RESERVOIRS.

Clean water may be piped directly from the camp's supply (Section X) to each laundry area, or water containers may be kept filled at the laundry site. Such containers can be improvised from cleaned oil drums, painted inside to resist weathering and rusting.

FACILITIES FOR HEATING WATER.

A single water heating device will provide hot water for washing as well as boiling water for sterilizing the washed clothes. (See figure 34.) A flash burner water heater of the type used for messkit washing (Section III) is ideal for this purpose; its capacity is about 70 gallons of boiling water.

Figure 34—Laundry Water Heater

SCRUBBING TABLES.

If no materials are available for constructing washing machines, a flat surface made of sheet metal or lumber in the form of a scrub table should be provided for scrubbing the clothes. Such a scrub table should slant so that the water will flow into a soakage pit. Reservoirs should be at hand for rinse water.

Washing Machines

1. PRINCIPLE.

A washing machine churns soapy water through the clothes, without beating the clothes themselves. Relatively little agitation of the water in the machine is required for effectiveness. Therefore, high-powered or high-speed machinery is unnecessary.

2. OPERATION OF WASHING MACHINES.

Hot water should be used in the washing machine. Take it from the water heater rather than heat it in the machine itself.

Add soap in the proportion of a half-bar of G.I. soap to a half-drum of water. It is best to add soap in melted or shaved form. After the churning action of the machine has whipped the soap into suds, add the clothes.

After using the machine, drain the heater and rinse barrels first into a grease trap to clear the water of soap, and then into a soakage pit or long soakage trench. (See figures 21 and 22.)

IMPORTANT

After washing, wring the clothes out and rinse thoroughly in clear water. In the tropics the laundering process should be followed by boiling for 5 minutes in the water-heating device. Such sterilization of clothes is important in preventing tropical skin diseases.

Construction of Washing Machines

1. HORIZONTAL ROTATING PADDLE WASHING MACHINE.

Support a 55-gallon drum in a wooden or welded metal framework. (See figure 35.) Cut a rectangular opening in the top side of the drum, and hinge the cut-away metal to the drum as a door. Construct the movable central shaft for use within the drum, attaching paddles as shown. Mount the shaft in position by a pipe flange welded at one end and by a bushing at the other.

On the outside of the barrel, fit the shaft from the bushing with an elbow and a short pipe and connect it to the drive shaft by means of a small universal joint or a bolt passed through the two flattened pipe ends (sliding joint). The jeep end of the drive shaft is fastened to the jeep hub with a flat metal strip, a bolt, and a tee pipe connection.

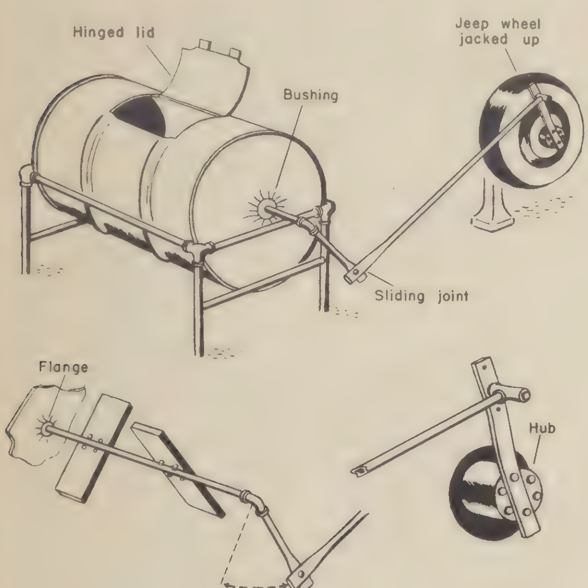

Figure 35—Horizontal Drum Type Rotating Paddle Washing Machine

2. VERTICAL DRUM ROTATING PADDLE WASHING MACHINE.

Place a 55-gallon drum in a vertical position over a shallow trench. (See figure 36.) Cut off and discard the upper third of the drum. Mount a central paddle shaft vertically in the drum by means of a 2 x 4-inch wooden block at the top and a pipe flange in the bottom center of the drum. Since the drive shaft from the jeep wheel describes a sidewise as well as an up-and-down movement, a small universal joint must be used to connect paddle and drive shafts.

Not more than two similarly constructed drums and paddle shafts may be connected in series with the machine shown in figure 36. Make the connections by means of flattened pipe ends bolted to form sliding joints.

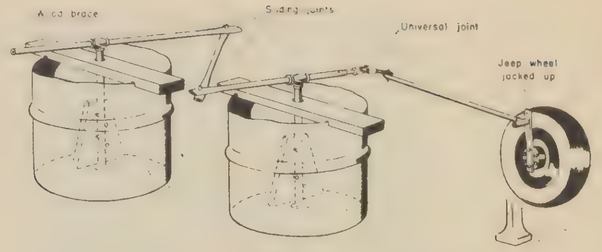

Figure 36—Vertical Drum Type Rotating Paddle Washing Machine

The drums are drained into the trench through the $\frac{3}{4}$-inch bung in the bottom. During use these bungs are stoppered with metal or rubber plugs.

3. ROTATING DRUM WASHING MACHINE.

Weld a flange and short projecting pipe to the center of each end of a 55-gallon drum. (See figure 37.) Mount the drum in a horizontal position on a simple trestle framework, so that the drum is supported loosely by the projecting pipes resting on the trestle.

Cut an opening in the drum, through which to feed the clothes into the machine. The opening should have a lid which may be hinged, if desired.

Attach the drive shaft to the drum by means of a short length of $\frac{3}{4}$-inch pipe threaded into the bung hole of the drum and locked there with a nut or pipe fitting. To give the drum a semi-rotatory movement, connect a drive shaft to the rear wheel hub of a jeep.

Bolt slats of wood about 1 inch square lengthwise inside the drum about $1\frac{1}{2}$ inches apart. Use enough slats to cover half or two-thirds of the lower inner sur-

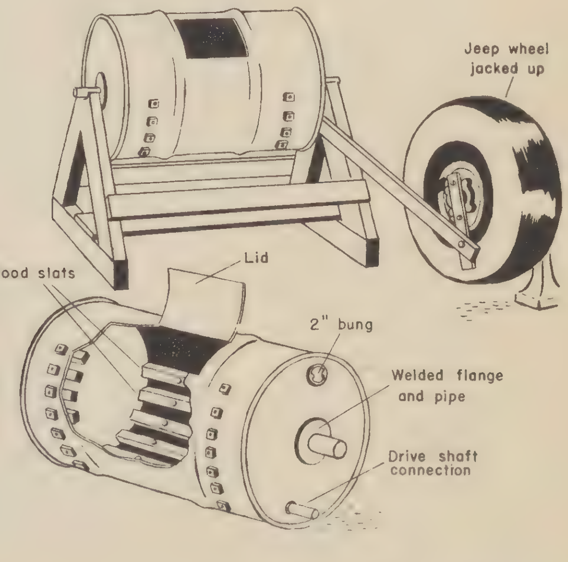

Figure 37—Rotating Drum Washing Machine

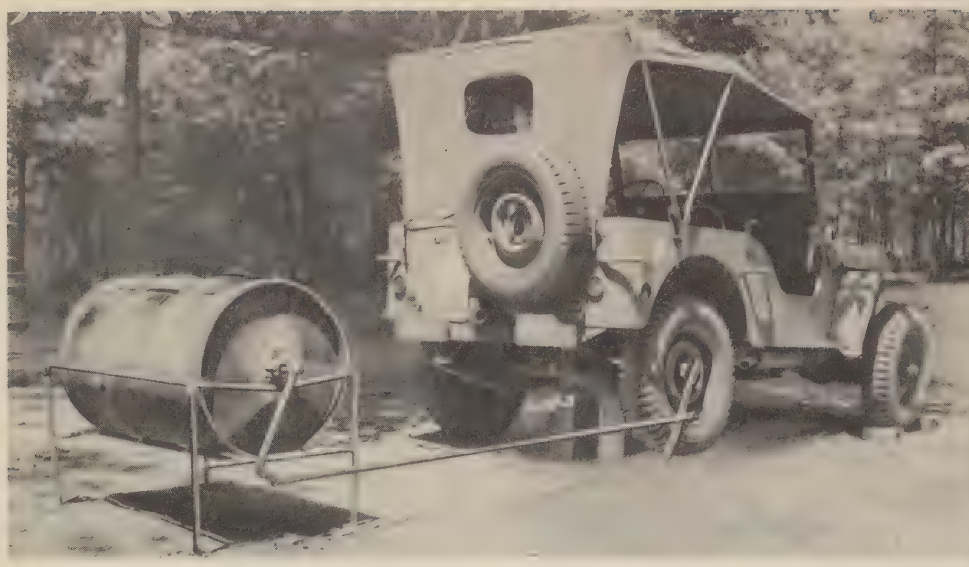

Figure 38—Jeep-Driven Washing Machine

face of the drum. Insert the slats into the drum through the 2-inch bung hole and secure them with round-headed bolts. Tighten the nuts on the outside of the drum. Swelling of the wood serves to make the bolt-holes watertight.

JEEP-DRIVEN OPERATION

To operate jeep-driven washing machines, jack rear wheel of jeep off ground. Run jeep at low speed. Allow 15 minutes of running time for each load of laundry.

4. SUCTION TYPE WASHING MACHINE.

A foot-operated machine can be readily improvised which agitates the soapy water by suction. (See figure 39.) Nail three No.10 cans with open ends to under surface of a notched wood block. Mount four slats in a drum or G.I. can along which the block will be guided as it rides up and down. The weighted suction board is raised and lowered by means of a cable running through two pulley devices to a foot-operated pedal.

Suction created by raising the open-ended cans agitates the water in the drum and washes the clothes by forcing soapy water through them.

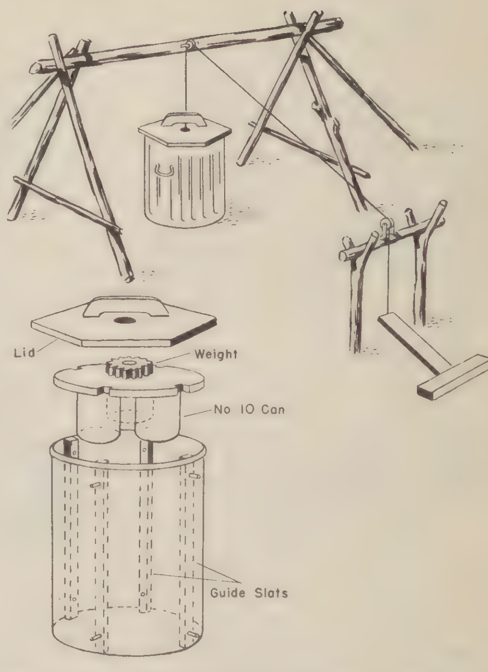

Figure 39—Suction-Type Washing Machine

SECTION IX

DRYING CABINETS

The use of cabinets for 24-hour drying of wet shoes, socks, and underwear will help reduce the number of cases of superficial skin infection and fungous diseases in the wet tropics. A simple electric bulb cabinet can be improvised that is both effective and practical. (See figure 40.)

Electric Bulb Cabinets

1. PRINCIPLE.

The air inside the drying cabinet is heated by an electric bulb. The warm air rises and escapes from vent-holes in the top of the cabinet, carrying moisture

with it. Outside air is drawn in through vent-holes in the bottom of the case.

About 10 watts are required for every cubic foot of space to dry wet clothes or shoes in a humid climate. One 100-watt bulb will serve 10 cubic feet.

2. MATERIALS.

Electric light bulb(s) of required wattage
Overseas packing case
Bulb socket(s)
Insulated wire
Heavy weatherproofing paper from packing cases

3. CONSTRUCTION.

Select an overseas packing case of desired size. Place it on end. Hinge the lid. Line the case with the heavy weatherproofing paper used in all overseas shipping boxes.

Install bulb socket(s) in the inside bottom of the lined case. Drill four 1-inch holes through the bottom and top of the case and its lining. Lead the wires to the socket through one of the bottom holes.

Install racks or hooks inside the lined case, for hanging shoes, socks and underwear. Drying is most rapid at the top of the cabinet.

4. USE.

Wet shoes, socks, and underwear (or other garments) are hung or placed inside the cabinet, and the lid is closed. Keep the bulb lit continuously while clothes are being dried.

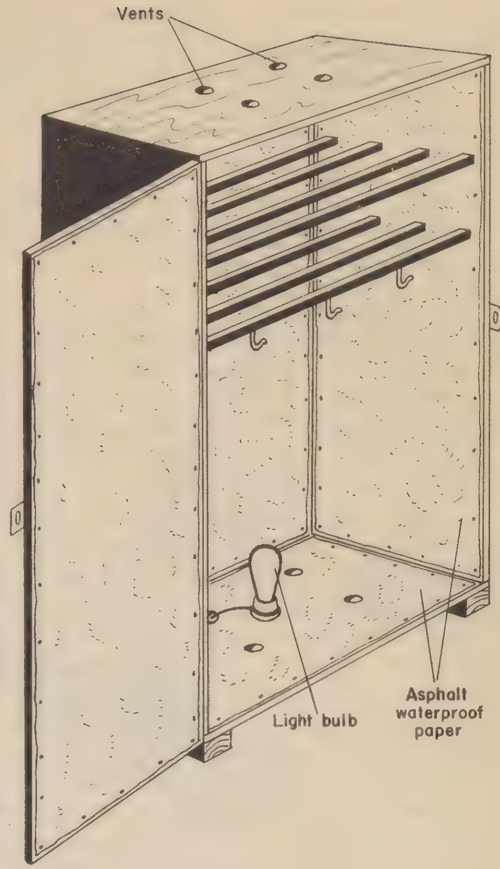

Figure 40—Drying Cabinet

SECTION X

WATER SUPPLY AND PURIFICATION

Under certain circumstances, isolated AAF units have been forced to handle their own water supply and purification, without the aid ordinarily given by the Corps of Engineers.

Water Sources

1. SURFACE WATER.

Surface water usually is abundant in the tropics, except on small islands and atolls. Such water often is loaded heavily with organic material and silt and must be purified by chemical treatment (flocculation) and settling. If a disagreeable odor and taste remain, it is desirable to break the water into droplets and expose to the air (aeration). *All surface water must be sterilized.*

2. SHALLOW GROUND WATER.

Many tropical combat areas have a high ground water table. Ground water may be made drinkable more easily than most tropical surface water, since it is clearer and has less organic material and coloring. For these reasons shallow ground water may be preferable to surface water even when the latter is more easily obtainable. *Shallow ground water must always be sterilized for military use.*

a. LOCATING GROUND WATER.—There are certain signs which indicate where shallow ground water will be most abundant:

The seepage of water through subsurface levels depends largely upon the porosity of the soil. Coarsely-grained soils such as gravel and sand are the most porous; finely-grained soils, the least. The mixture of clay or silt with coarser sediment greatly reduces porosity. For example, coral is porous and drains rapidly, whereas clay, gumbo, silt, swamp muck, and peat drain slowly. Water is most abundant in porous soils.

In a flat terrain the presence of a small meandering stream indicates that the soil is fairly heavy and

nonporous. Drainage is by surface run-off. The absence of meandering streams in a flat terrain generally means that rainfall is largely absorbed by the soil with little or no surface run-off and that the soil is porous and has good underground drainage.

The flood plains of streams are favorable locations for the collection of shallow ground water, if they contain coarse sand and gravel.

b. METHODS OF COLLECTION.—Shallow dug wells and infiltration galleries are used to collect shallow ground water. Infiltration galleries are essentially shallow dug wells with long extending arms. (See figure 41.) To minimize labor, they should be constructed in areas where the water table is not more than 8 feet. Dig a hole 3 to 4 feet in diameter and several feet below water level. This is the pumping point. Dig trenches a foot or more below water level, extending horizontally in both directions along the contour lines from the pumping point. Case the pumping point with open-ended 55-gallon oil drums, stacked end on end in the hole. Perforate the casing drums with many pick-holes before placing them in position in the hole. Fill the trenches to the water line with logs. Cover the logs with thick layers of saplings, branches, and leaves. Pile dirt over these layers up to the surface of the ground. The yield of galleries is in proportion to their length and to the porosity of the soil. The galleries are most suitable when constructed at the base of a slope, at the edge of a marsh, pond, or lake, or along a river bank.

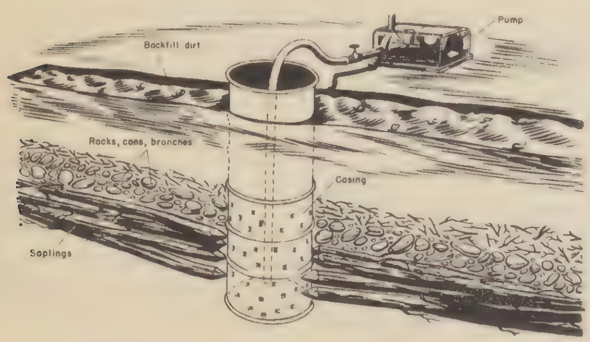

Figure 41—Infiltration Gallery

3. COASTAL WATERS.

On small islands and atolls, the chief water supply is distilled seawater. However, in many coastal areas large quantities of fresh drinking water may be pumped from shallow wells and galleries. Fresh water is found slightly above sea level and may extend to a considerable depth below sea level. *In porous soils in coastal areas, about 40 feet of fresh water lie below sea level for each foot of fresh water above sea level.*

In coastal areas the infiltration gallery is the ideal method of collecting ground water. By spreading the pumpage over a wide area, the gallery lowers the fresh water level as little as possible and avoids the danger of contaminating the fresh water layer with salt water from below.

4. RAIN CATCHMENT.

In areas having daily rainfall, rain catchment is an important source of water. For example, in the central Pacific islands every shelter has a rain barrel.

Improvised Methods of Pumping Water

1. DECONTAMINATING APPARATUS, M3A1 AND M4.

Every AAF unit overseas is equipped with decontaminating apparatus M3A1 or M4. In accordance with WD Training Circular 101, 1943, this apparatus may be converted into a water pump and 400-gallon storage tank.

2. AIRCRAFT PUMPS.

The motor-driven booster pumps which are used on aircraft to transfer fuel from one tank to another may be used for pumping water. These centrifugal pumps revolve at high speed and may pump from 250 to 300 gallons of water per hour with a discharge head between 15 and 40 feet. Such airplane pumps can be run by electricity from a 28-volt energizer (generator) salvaged from an airplane.

3. FUEL TRANSFER PUMPS.

The transfer of fuel from tank cars to drums and from drums to airplane tanks is accomplished by gasoline-motor driven pumps or by hand pumps. These pumps are also suitable for pumping water. A fuel transfer pump assembly can pump about 1200 gallons of water per hour through 1 1/4-inch pipe, with a discharge head of about 25 feet.

4. SUGGESTIONS FOR USE OF SUCTION PUMPS.

a. Locate pump close to water level. This reduces the load on the pump. Most pumps fail if the suction drag exceeds 18 feet.

b. Cap the water intake with a screen strainer having apertures which total at least three times the cross-sectional area of the suction pipe. This minimizes hydraulic loss at the screen.

c. Place the intake strainer about halfway between the bottom and the surface of the water source.

d. An excellent method of collecting partially purified water from a muddy stream is by use of a water seepage barrel. Remove both ends of a clean oil drum. Sink the drum into the stream bed in about 2 feet of water. Leave the top end of the drum a few inches above the stream surface. Water filling the drum from below will be partially filtered by seepage through the

stream bed. Suspend the water intake strainer inside the drum.

e. Hydraulic loss caused by the friction within pipes is minimized by using large bore pipe with as few elbows as possible. With a 50-foot length of pipe or less, this friction loss is negligible.

f. The combination of two centrifugal pumps in series doubles the discharge head without increasing the total flow of water. Placed in parallel, such pumps will double the flow of water, but at the same discharge head.

Storage Of Water

Water may be stored in the following ways:

1. In the 400-gallon tank of decontaminating apparatus, M3A1 or M4.
2. In cleaned oil drums or gasoline drums, G.I. cans, or other metal containers. Gasoline drums must be soaped and rinsed, then treated with activated carbon and rinsed. (See T.O. No.12-1-11.)
3. In pits lined with soil cement.
4. In pits lined with waterproofed canvas.

Salvaged tent canvas may be repaired and processed to serve as an adequate water reservoir. Patch any holes from the inside with canvas scraps and tent patching cement. Coat seams with this cement. Then give the entire container two or more coats of airplane dope (waterproofing fabric compound, Stock No. 7300-249000). Set the completed bag into a pit, with 6 or 8 inches of edge left free to be secured to a wood rim. The bag should be covered with canvas to keep dirt from being kicked into the reservoir. The emptied bag can be lifted out for repair or cleaning.

Purification Of Water

(See figure 42.)

Purification of water is accomplished most effectively by successive steps of flocculation, settling, and filtration. Filtration alone is inadequate. *Purified water must be sterilized.*

1. FLOCCULATION AND SETTLING.

The addition of coagulants (such as alum) to water causes a gelatinous material to form. In settling, this material absorbs and carries down any particles of matter and serves to clear the water. The gel and the impurities it picks up is called "floc."

The successful formation of a floc depends upon adding the correct amount of coagulating chemicals to the water. Since all waters vary in their alkalinity and in their mineral content, the amount of chemicals needed for flocculation also varies.

For improvised emergency water purification, the best procedure is to cause a floc to form in most types of water by using large amounts of the necessary chemicals. *The amounts specified in the table following should be regarded as the maximum amount of chemicals needed for most water. Smaller amounts should be used if a good floc can still be produced.* Experimental trials should be run on small quantities of water in Lyster bags, in order to determine the most economical quantity of chemicals required to produce flocculation.

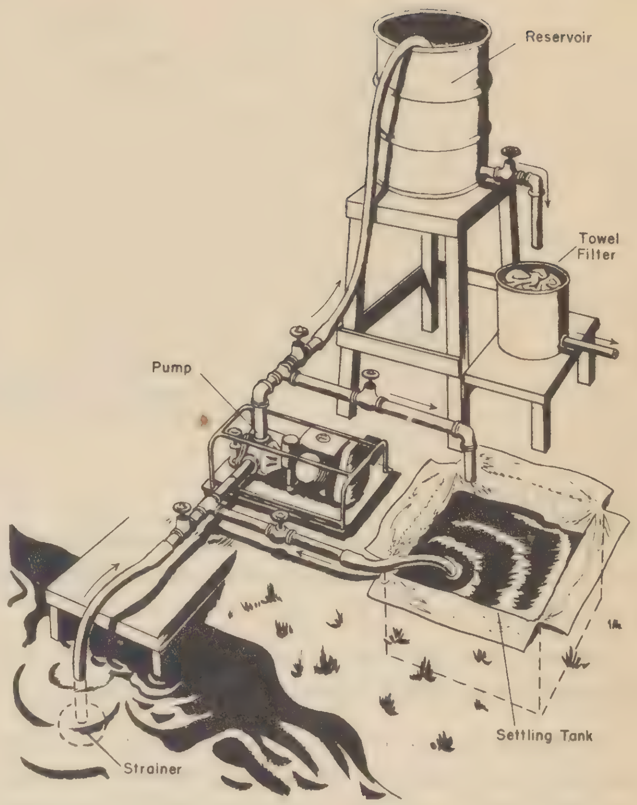

Figure 42—Schematic Layout of Water Supply and Purification

To purify water by flocculation, proceed as follows:

a. Dissolve the alum specified in table 1 in a bucket of water and then add to the water in the settling tank; agitate the water while adding.

b. Dissolve soda ash (or hydrated lime), as specified in the table, in a bucket of water and add it to the settling tank immediately after the alum. Do not mix the alum and soda ash (or lime) directly together.

c. Agitate the contents of the reservoir with a paddle for at least 5 minutes.

d. Allow the floc that forms to settle to the bottom. This will take 60 minutes or more. If much floc rises to the surface, the quantity of alum should be reduced in succeeding purifications.

e. Pump off the cleared water on top.

TABLE 1

Quantity of Water to be Purified	Maximum Amounts of Chemicals Required to Produce Flocculation		
	ALUM	SODA ASH or	HYDRATED LIME
Lyster bag or 35-gallon G.I. can	Wt 1/3 ounce Vol 2/3 spoonful	Wt 1/7 ounce Vol 3/5 spoonful	Wt 1/10 ounce Vol 2/5 spoonful
55-gallon oil drum	Wt 1/2 ounce Vol 1 spoonful	Wt 1/4 ounce Vol 1 spoonful	Wt 1/6 ounce Vol 2/3 spoonful
100-gallon container	Wt 1 ounce Vol 2 spoonfuls	Wt 1/2 ounce Vol 2 spoonfuls	Wt 1/3 ounce Vol 1-1/3 spoonfuls
3000-gallon container	Wt 2 pounds Vol 1-1/2 cupfuls	Wt 1 pound Vol 4/5 cupful	Wt 2/3 pound Vol 1-1/3 cupfuls
	Cupful: level canteen cup—22 ounces volume Spoonful: level messkit tablespoon—1/2 ounce volume		

2. FILTRATION.

The smallest particles of floc must be removed from the water by filtration. Place the filter at either the inlet or outlet of the water reservoir.

Improvise a filter by packing a small drum with ordinary clean toweling or a G.I. wool blanket.

In the tropics an improvised sand filter cannot be relied upon because of the high turbidity of the water and the difficulty of procuring sand which is clean and of the proper grain size.

3. AERATION.

If the water has a disagreeable odor, it should be "aerated." This involves breaking the water into droplets so that gases contained in it will be freed. When pumping the cleared water into a storage tank, aerate by running the water through a large screen strainer at the discharge outlet, by splashing it against a deflecting surface, or by running it through a narrow sluice filled with baffles.

4. STERILIZATION.

Sterilize all water used for drinking, washing, and for the mess by the prescribed methods.